

February 16, 2005

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Bureau of Land and Water Quality
State House Station #17
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Dear Mr. Mitnik:

The National Council for Air and Stream Improvement (NCASI) is a technical environmental research organization founded in 1943 and funded primarily by the U. S. forest products industry. Our membership represents over 95% of U.S. pulp and paper production. We have a long history of research and experience in water quality modeling and TMDLs. We recently completed a TMDL study for the Alabama Department of Environmental Management (NCASI 2004a). We frequently perform technical reviews of TMDL studies, particularly when our member companies are involved, to help ensure that decisions based on the TMDL are being made with a sound scientific basis.

The following comments are based primarily on a review of the draft “Androscoggin River Total Maximum Daily Load” (2004) report and “Androscoggin River Modeling Report and Alternative Analysis” (2002) report. The approach taken to developing these comments is an evaluation of the methods used and assumptions made by the State of Maine in comparison to NCASI’s research findings and experience with the proper application of water quality models. Based on this evaluation, it is NCASI’s opinion that the predictive ability of the water quality models has not been shown to be sufficiently reliable for use within a far-reaching environmental decision support context. Furthermore, the model’s multiple conservative assumptions, when taken in total, result in an overly conservative model that can lead to excessively costly and difficult to achieve license limits for point source dischargers that, because of uncertainties in model predictions, may actually fail to fully address the true causes of the impairments.

The following are specific comments in regards to the model application and implementation.

1. The calibration and validation phase of the model building process is compromised by the use of the vertical dispersion rate as an adjustable parameter.

The 2002 Androscoggin River Modeling Report (pages 21-22) details the calibration of the model to dissolved oxygen data. The report states that the main calibration parameters were BOD decay rate, reaeration rate, and vertical dispersion rate. The vertical dispersion rate was used to account for modeled vs. measured dissolved oxygen discrepancies which were attributed to variable

mixing conditions during the calibration period. This method is a potentially large source of uncertainty to the model because the variable vertical dispersion rates can be used to compensate for errors in other parameters such as BOD decay, reaeration, and SOD. In this way the vertical dispersion rate is an additional free parameter in the dissolved oxygen balance.

The proper calibration of a robust water quality model is achieved through defining many system specific input parameters through measurement and reducing the number of free parameters available to the modeler. The greater the number of free parameters in the model and the greater the possible range of these parameters the higher the model uncertainty. In this model there are three identified calibration parameters.

In most water quality calibration procedures the hydrodynamic characteristics of the model are calibrated separately from the water quality characteristics to eliminate the potential use of hydrodynamic parameters to calibrate water quality values. In nearly all of the recent (2001 – present) water quality models that NCASI has reviewed for vertically stratified systems, a separate hydrodynamic model has been used to independently calculate vertical dispersion. Many of the most widely used models for impounded systems such as the Army Corps of Engineers model CE-QUAL-W2 have internal hydrodynamic mechanisms to calculate vertical transport. The US Environmental Protection Agency's WASP model allows the import of hydrodynamic model output from models such as the Environmental Fluid Dynamics Code (EFDC) and others. These observations on the current state of the science of the modeling of vertically stratified systems imply that water quality modeling experts in government, industry, and academia have acknowledged that the use of hydrodynamic transport parameters for calibrating a water quality model is a significant source of uncertainty in the calibration which can be alleviated with modern methods.

An additional concern about the calibrated vertical transport parameters and the characterization of total transport in the pond relates to the use of the model as a tool for the design and operation of the oxygen injection system. The large degree of uncertainty in the characterization of transport in the pond is a significant limitation when evaluating the mitigating effects of oxygen injection, especially in the lower reaches of the pond. The model's current characterization of transport is not adequate for this type of use.

2. The methods used to predict sediment oxygen demand (SOD) under various point source loading scenarios are overly simplistic and not appropriate for this model.

Sediment oxygen demand (SOD) is the most significant oxygen sink in the Gulf Island Pond model as indicated by sensitivity analysis. Many if not all of the far reaching environmental decisions that may depend on this model's predictive output are based primarily in the linkage between the point sources and the dissolved oxygen deficit caused by SOD. However, the calculation method the model uses to arrive at SOD values for calibration and also for predicting SOD at different point source loadings is an approximation that is not appropriate for use in this predictive model.

While SOD is incorporated in the WASP5 model as an oxygen sink, it is calculated as a function of organic carbon flux (both algal and TSS) to the sediment bed outside of the WASP5

framework. Unlike the WASP5 model, the SOD calculation method is not peer reviewed nor is its use cited for any previous SOD modeling effort. In addition, no data have been collected to verify the method's predictive ability under various point source loading conditions. Data collection efforts that develop a solids balance around the pond would provide valuable information for testing the current SOD analysis.

One apparent problem with the method is that it assumes a linear relationship between organic carbon flux to the sediment and resulting SOD. Research into the modeling of SOD has shown a more complex, non-linear relationship. The mechanisms that result in this non-linear relationship (summarized in DiToro et al. 1990) are being incorporated into several popular water quality models including QUAL2K, WASP6, WASP7, and CE-QUAL-W2. The non-linear relationship specified in these models may have significant implications for the predicted SOD rate under forecasted loading conditions.

3. The non-algal diurnal dissolved oxygen adjustment in the deeper parts of the pond is not linked to any natural process simulated by the model and is not predicted by the model. This represents a significant uncertainty in the water quality model.

Page 52 of the Androscoggin River Modeling Report describes data from a continuous monitor showing diurnal fluctuation of dissolved oxygen in which minima and maxima do not always occur in the early morning and mid-afternoon, respectively, as would be expected from algal respiration and photosynthesis. In addition, this fluctuation also occurs in the lower depths of the pond where algal activity is not expected. The fact that the magnitude of this fluctuation is continuous and consistently around 0.8 mg/L indicates that it may be the result of some periodic hydraulic process not captured by the model. In any case, this phenomenon should be more rigorously characterized and linked to some understood process before its result (a 0.4 mg/L oxygen deficit) is attributed to the point sources. This point also relates to a following comment on multiple layers of conservatism.

4. The assignment of different BOD decay rate constants to the pond for different point source loads is not appropriate.

Increasing the BOD decay rate constant as a function of an increase in the modeled BOD discharges from the mills is inappropriate in this case. Common practice in water quality modeling is not to adjust such parameters without a firm scientific basis for doing so. The adjustment assumes that the materials discharged at the higher rate are of a different and more degradable quality than those discharged at the lower rates. This assumption is based on the hypothesis that the calibrated BOD decay rate in 1984 (0.05 per day) and 2000 (0.03 per day, which was also lab verified) is different because of the much lower BOD level experienced in 2000 (Androscoggin River Modeling Report 2002). This assumption is then used to increase the BOD decay rates for TMDL and licensed-load prediction runs by 33% and 66% respectively. This logic is faulty because today's effluents are not comparable to those in the 1980s. There have been changes in the processes that generate the effluents (e.g. conversion to ECF bleaching, implementation of spill controls and other BMPs, changes in process additives), as well as the treatment processes used at the mills. In any event, the justification for the magnitude of the decay adjustment (33% and 66%) is not tied to any quantitative, site-specific analysis and is

therefore speculative. Because there is no scientific basis for assuming this situation, the adjustment should not be made in the model.

5. The assignment of different BOD decay rate constants to the pond for different point source loads is not consistent with the BOD decay rates assigned to the river.

The argument is made that under simulated higher point source effluent flow conditions (i.e. licensed loads) the BOD discharged will have a higher decay rate constant. While we disagree with this argument (see Comment #4), we note that the BOD decay rate constant entered into QUAL2E for simulated high point source effluent flows are held constant under all effluent flow conditions. This is contradictory to the argument being made by the State of Maine that higher effluent flows result in higher decay rate constants. A higher decay rate constant in the QUAL2E model will have the effect of lessening BOD boundary loads to the WASP5 Gulf Island Pond model. As detailed in Comment #4, we do not think there is sufficient scientific evidence to support discharge-variable BOD decay rates.

6. It is inappropriate to assume that Gulf Island Pond is not well mixed chemically but is well mixed thermally.

Typically, thermal gradients act as a significant driving force in the vertical mixing of deep waters. At temperatures above 4°C, warmer water is less dense and thus floats on top of colder water. This phenomenon causes a low amount of chemical mixing over significant periods of time and results in much colder water residing near the bottom of the pond. The opposite is typically true in well mixed ponds where much of the depth of the pond is the same temperature and chemical mixing throughout the depth of the pond is higher. The Gulf Island Pond model assumes a contradictory combination of high thermal mixing and low chemical mixing which generates a result of lower dissolved oxygen saturation level and increased chemical decay rates combined with little mixing of oxygen from the surface layers. Simulating this highly improbable condition is one way in which the model is over-conservative.

7. The model's characterization of organic phosphorus for paper mill effluents does not agree with recent research.

NCASI Technical Bulletin 879 (2004b) investigated the degradation properties of organic nutrients from pulp mill effluents. The study used treated effluents from four mills representing four different types of pulp manufacturing. This research found that over the 91 day study period, 59 to 68% of the organic phosphorus degraded into the inorganic, available form. The majority of the degradation occurred over the first three weeks of the study while the remaining fraction degraded at a slow rate over the final 10 weeks. The current water quality model lumps organic phosphorus into a single compartment which allows organic phosphorus to decay nearly completely. The most recent state of the science nutrient models such as the Army Corps of Engineers model CE-QUAL-ICM acknowledge a dual compartment characterization of organic nutrients by including both refractory and labile organic nutrient compartments with separate decay rates. The inclusion of all organic phosphorus under a single decay rate may significantly overstate the impact of pulp and paper mill discharges of organic phosphorus on algae growth

because it is likely that only a smaller fraction of the organic phosphorus is available for decay over the residence time of the river / pond system.

8. The development of the model's ortho-phosphorus uptake rate is based on incomplete information and needs additional study.

A key factor in the phosphorus TMDL is the estimation of total and ortho-phosphorus assimilation between point source discharges and the entrance to Gulf Island Pond at Twin Bridges. The draft Androscoggin River Total Maximum Daily Load (2004) report states that 2004 data show “rapid loss of ortho-P” between Berlin and Jay, while “ortho-P appears to remain nearly constant from Jay to Turner implying a low ortho-P assimilation rate” (page 10). Corresponding rates used in modeling, according to the report are “2.3 and 3.5/day, respectively in Berlin and Rumford but as low as 0.01/day from Jay to Turner.” The rates for these sections of river differ by more than two orders of magnitude, which the report ascribes to differences in water depth and the free-flowing nature of the river at these locations (shallower and more free-flowing upstream of Jay). While some differences may exist, we note that estimated travel time (Maine DEP 2002) and elevation change other than at dam locations (based on an analysis of topographic data using the USGS National Map Viewer on-line at <http://nmviewogc.cr.usgs.gov/viewer.htm>) are not substantially different. In addition, certain characteristics provided in the EPA Reach File hydrographic database for river segments from Rumford to Jay and from Jay to the Nezinscot River are also relatively similar (similar mean depths and mean and 7Q10 flows and velocities). Consequently, it is difficult to believe that such a large difference in phosphorus assimilation rates is real. It is equally plausible that phosphorus sources and dynamics in the river are not yet understood well enough to support reliable predictions of the point source phosphorus loadings to Gulf Island Pond. For example, there may be a higher proportion of agricultural land adjacent to the Androscoggin River in the river reach between Jay and Gulf Island Pond compared to the reach between Rumford and Jay (a brief review of USGS Land Use Land Cover Data and other observations support this). Are there other sources of ortho-P such as agricultural run-off, river sediments, or wetlands between Jay and Gulf Island Pond which could explain the apparent lack of ortho-P assimilation in this river reach?

Further, the only apparent verification of model predictions for phosphorus assimilation comes from observations made between July 21 and August 11, 2004. Verification data consist of four weekly observations at any single point in the river. This is a relatively small number of data points collected over a limited time frame upon which to verify model predictions used to support decisions with such important environmental and economic implications. We further note that the wet, cool conditions of the summer, as pointed out in the draft TMDL report, are not representative of the low flow, warm summer temperature conditions being modeled. We agree with Maine DEP that using data generated during the wetter, cooler period (2004 data) to predict phosphorus utilization during low flow summer conditions when river water travel times and temperatures are higher is problematic. Model predictions for low flow conditions should be corroborated with field data from a period that is more representative of low flow summer conditions before a definitive TMDL is established.

9. It is not appropriate to develop a chlorophyll-a threshold for an algae bloom based upon a single event.

There is little basis for establishing 10 ppb as the threshold for algae blooms in the TMDL. Page 5 of the report states “There does not appear to be a good relationship between algae blooms and chlorophyll-a at any given location.” However, the report goes on to suggest that using “pond averaged chlorophyll-a,” “a good relationship is apparent in the chlorophyll-a data and observed blooms.” This is based on the observation of a pond average chlorophyll-a value of 10 ppb occurring simultaneously with a bloom on August 4. This single observation of paired bloom-chlorophyll-a data is not a sufficient basis for a TMDL. The report acknowledges the need for additional data to better link phosphorus and chlorophyll-a levels to algae blooms. It is therefore premature to use a value of 10 ppb to establish a definitive phosphorus TMDL for this system.

10. The model’s multiple layers of conservative assumptions result in a margin of safety that is undefined and likely overly conservative.

The model relies on an implicit margin of safety resulting from several assumptions made during in the modeling process. Among these assumptions is selection of the model parameters that resulted in the highest predicted chlorophyll-a concentration for Gulf Island Pond as the basis for the phosphorus TMDL. A higher CBOD decay rate (0.04 per day) was used compared to the 0.03 per day rate that was measured and calibrated from the 2000 modeling effort. All point sources are assumed to discharge their allocated waste load simultaneously during a 10-year low flow event. The report acknowledges that “the probability of this occurring would be low” (page 3). Another conservative assumption is the inclusion of a 0.4 mg/L dissolved oxygen deficit (determined through observation of monitoring data in Gulf Island Pond and not explained by the model) as part of the minimum dissolved oxygen criteria to be achieved by point source reductions. In addition, Gulf Island Pond is characterized as chemically stratified but thermally mixed. While the validity of this assumption is commented on above (see Comment #6), its inclusion represents an additional layer of conservatism. These assumptions compound to create an implicit margin of safety that is undefined, is likely overly conservative, and that may preclude accurate model predictions.

Regarding the margin of safety, the draft Guidance for Water Quality Based Decisions: the TMDL Process (USEPA 1999) states that among the factors that should be considered in evaluating and deriving an appropriate MOS is expressing the results of a TMDL analysis in terms of confidence intervals or ranges. These confidence intervals are not identified in the draft Androscoggin TMDL report. Without a credible effort to establish confidence limits, there are few constraints on the reasonableness of the MOS. An additional factor to be considered according to this draft guidance is the “implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.” This information is not provided in the draft TMDL and is warranted given the magnitude of the environmental decision and the potential implications of this TMDL.

11. The TMDL for total suspended solids (TSS) is based on incomplete data; therefore it is premature to establish a definitive TSS TMDL.

As with the CBOD and phosphorus TMDLs, there is a high degree of uncertainty associated with the draft TSS TMDL. For example, the draft TMDL for the Livermore Falls Impoundment aquatic life criteria, which attempts to develop a relationship between point source TSS loads and attainment/non-attainment status of aquatic life criteria, is based on the results of rock basket studies conducted in several years between 1995 and 2004 (non-point TSS concentrations were assumed to be stable during each period analyzed). The report points out, however, the contrary observation that “[t]he lowest TSS load to the Livermore Falls impoundment occurred in 2002, yet non-attainment of class C aquatic life criteria occurred in that summer.” The report later discusses the potential that the non-attainment observation was due to the absence of a “large runoff event that could help flush the bottom of solids that have settled onto benthic organisms” and states that “[w]ithout an additional summer of macroinvertebrate data collected under low flow and low runoff, it is difficult to explain the apparent contradiction of the 2000 and 2002 aquatic life evaluations.”

In spite of the highly uncertain relationship between point source TSS loads and attainment of aquatic life criteria, DEP chooses in the draft TMDL report to remove the 2002 data from the TMDL calculation as “an anomaly until more data can be collected at summer low flow conditions that indicate this calculation is incorrect” in order to proceed with the establishment of an aquatic life-based TSS TMDL and point source allocation. In this light, it is reasonable to conclude that any allocation of point source loads to the river will be highly uncertain, and considerably more information is needed before an appropriate TSS load allocation, or the effectiveness of such an allocation, can be determined. We note that without 2002 data, the only other class C aquatic life non-attainment observation for the Livermore Falls Impoundment occurred in 1995, nearly 10 years ago.

Table 12, according to the report text on page 43, contains a “summary of actual loads to the Livermore Falls impoundment.” It is not clear how these loads were derived. They appear to be estimates based on model results rather than “actual” load values.

12. Maine DEP should provide more information on how the recommended “phased” TMDL for CBOD, phosphorus, and TSS would be implemented, including a more detailed monitoring plan.

We agree with Maine DEP’s assessment (see page 4 of the TMDL Summary) that, if a TMDL needs to be established, a “phased” TMDL is appropriate for all TMDL targets on the Androscoggin River and Gulf Island Pond in light of the significant uncertainties in model predictions that remain. However, it is not clear what direction DEP intends to take with respect to such a phased approach. The current draft incorporates several conservative assumptions, resulting in a large undefined MOS and potentially overly restrictive, difficult-to-implement, and potentially ineffective (i.e. fail to fully address true causes of impairments) license limits for point source dischargers. This draft does not, therefore, reflect a “phased” approach.

One element of adaptive implementation, according to EPA Region 1 guidance on nutrient TMDLs for lakes and reservoirs (USEPA 2005), is a monitoring plan “that describes the additional data necessary to determine if the load reductions required by the TMDL will lead to attainment of water quality standards” (page 9). Such a monitoring plan is not currently incorporated in the draft Androscoggin River TMDL.

Conclusions

NCASI believes that the modeling effort put forth by the State of Maine represents a large step forward in the understanding of the linkage between point and non-point sources on the Androscoggin and resulting water quality. However, the comments above illustrate the problems with using the water quality model as it is currently configured as a decision support tool that requires a high degree of predictive accuracy.

Much has been accomplished in recent years toward characterizing the extent of the relationship between point and non-point source discharges and non-attainment of water quality standards in Gulf Island Pond. Nonetheless, the draft Androscoggin TMDL report acknowledges that many areas of uncertainty remain in the predictions made by the Androscoggin River and Gulf Island Pond water quality models. Additional studies as described above can substantially reduce these uncertainties. In combination with the large environmental and economic implications of the decision that these models support, a phased, adaptive implementation approach is clearly warranted. The draft TMDL report should more fully describe how this approach would be implemented for this ecosystem.

Sincerely,

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Enclosures (1)

cc: Paul Wiegand (w/o enclosure)
Jay Unwin (w/o enclosure)
Doug McLaughlin (w/o enclosure)

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